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METAMORPHISM OF THE ODDANCHATRAM ANORTHOSITE, TAMIL NADU, SOUTH INDIA.

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The Oddanchatram anorthosite [1,2] is located in the Madurai District of Tamil Nadu, near the town of Palni. It is emplaced into a granulite facies terrain commonly presumed to have undergone its last regional metamorphism in the late Archean about 2600 m.y. [3]. The surrounding country rock consists of basic granulites, charnockites and metasedimentary rocks including quartzites, pelites and calc-silicates. The anorthosite is clearly intrusive into the country rock and contains many large inclusions of previously deformed basic granulite and quartzite within 100 meters of its contact [2]. Both this intrusion and the nearby Kaduvar anorthosite show evidence of having been affected by later metamorphism and deformation.

The anorthosite is typical of Proterozoic anorthosites in that it is largely massive and coarse-grained, containing on average more than 90 percent plagioclase (An_{59-51}) and has associated lenses rich in Fe-Ti oxides. Plagioclase is variably recrystallized: it generally displays abundant, strongly curved secondary twinning and has strongly sutured boundaries. The most common mafic minerals are hornblende, augite and orthopyroxene. Hornblende and some pyroxenes probably crystallized during metamorphism, but some pyroxene also occurs in primary igneous textures. Garnet occurs locally as equant crystals in thin discontinuous bands, but has not been found as a reaction rim between plagioclase and pyroxene. Although delicate primary igneous features are locally well preserved, this anorthosite appears to have been strongly affected by deformation and metamorphism after its emplacement. The rocks do not appear to have suffered significant strain after the growth of garnet.

Intrusive contacts of the anorthosite with the surrounding country rock are well exposed. Sharply bounded dikes of relatively fine-grained anorthosite occur at a few locations; some are tightly folded. Anorthosite near the contact commonly contains abundant elongate inclusions of basic granulite and lesser amounts of garnet-bearing quartzite. Post-emplacement deformation is indicated by a locally strong penetrative fabric and by boudinage of some inclusions. Assimilation of metasedimentary rocks appears common along some portions of the contact: where calc-silicate rocks have been incorporated the anorthosite is abnormally calcic and where pelitic rocks have been incorporated the anorthosite contains discontinuous zones with disseminated quartz and equant garnets [2]. Most garnets are partly or completely replaced by delicate symplectites of hypersthene and anorthite.

Mineral assemblages useful for thermobarometry are found in the anorthosite and in the surrounding country rock.

Anorthositic rocks locally contain garnet, quartz, orthopyroxene and clinopyroxene in addition to the dominant intermediate plagioclase. Pelitic country rocks contain an early assemblage of rutile, garnet, sillimanite, and quartz which has partly reacted to produce prominant rims of cordierite between garnet and sillimanite. A charnockite located roughly two km south of Oddanchatram contains the assemblage, quartz-plagioclase-orthopyroxene-garnet.

Although some garnets in anorthosite lack symplectite rims and occur in sharp contact with primary intermediate plagioclase, they more typically have broad, essentially unzoned cores and narrow rims depleted in Ca where they are in contact with surrounding symplectites of orthopyroxene and anorthite. Garnet in the pelitic rocks is much lower in grossularite component and essentially unzoned. In the charnockite it is also unzoned and very low in MgO. Orthopyroxenes in anorthositic rocks have Mg/(Fe+Mg) of roughly 0.55. Neither pyroxene is significantly zoned. Orthopyroxene in the charnockite has much lower Mg/(Mg+Fe). Primary plagioclase in the anorthosite ranges from about An46 to An55. Plagioclase in the symplectites is between An95 and An85. In the charnockite it is An34.

Metamorphic equilibration temperatures in the anorthosites, based on coexisting garnet and clinopyroxene, range from a maximum of about 920°C to about 700°C. It has not been possible to determine a maximum temperature of metamorphism in the country rocks. The assemblage, garnet-cordierite, is widespread in the pelitic rocks but is retrogressive. These minerals are essentially unzoned and yield temperatures between 780 and 700°C - temperatures that closely match the minimum temperatures recorded by symplectites in the anorthosite. The relict assemblage, garnet-sillimanite-quartz-rutile, could have been stable at much higher temperatures.

Estimates of pressures within the anorthositic rocks are based on the association of garnet-plagioclase-quartz with orthopyroxene or clinopyroxene. Garnets that lack symplectite rims and the cores of other garnets yield estimates of about 11.3 kb at 920°C. Garnet rims in equilibrium with surrounding anorthite-hypersthene symplectites yield estimates of from 7.3 to 5.6 kb at 775°C. Pressures estimated for the pelitic rock are based on the retrogressive assemblage, garnet-cordierite. The model of Aranovich and Podlesskii [4] yields pressures of from 7.7 to 7.2 kb. These pressures are consistent with the minimum values recorded by symplectite assemblages in the anorthosite. The relict assemblage, garnet-sillimanite-quartz- rutile, could have been stable at the highest pressures and temperatures determined for the anorthosite. In the charnockite, the assemblage, quartz-plagioclase-orthopyroxene- garnet, yields an estimate of 8.8 kb, assuming a temperature of 900°C.

Because the Oddanchatram anorthosite should be similar in age (ca. 1400 my) to the Chilka Lake anorthosite [5] the metamorphism of the Oddanchatram anorthosite should record crustal conditions in this part of the south Indian shield during the middle to late Proterozoic. Temperatures and pressures reported for other rocks in this portion of the shield (e.g. rocks near Madurai and Kodaikanal [6]) may therefore be a record of Proterozoic rather than late Archean metamorphism.

The maximum pressures reported here require that Archean supracrustal rocks in the southeastern portion of the south Indian shield were buried to depths of 35 km in the middle Proterozoic. Because the present crustal thickness is still about 40 km [7] and because there is no evidence for post-anorthosite underplating, the crustal thickness in this part of the shield during the middle Proterozoic should have been roughly 75 km. The production of such abnormally thick crust could be explained by continental collision and underthrusting of the eastern margin of the south Indian shield beneath a converging continent. The Eastern Ghat orogenic belt, which lies roughly 100 km east of the Oddanchatram anorthosite, is thought to be such a mid-Proterozoic collisional belt [8]. Metamorphic mineral ages of 1000 my [9] in this belt suggest that the Eastern Ghat orogenic event could have been responsible for the metamorphism and deformation of the Oddanchatram anorthosite.

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